NSF STEM-C Proposal

Earth SySTEM: Observing the Earth - Visualizing the Future

A New Lens for Integrating Computing Science in STEM Education

**ABSTRACT:**

The “Earth SySTEM: Observing the Earth and Visualizing the Future … a New Lens for Integrating Computer Science in STEM Education” project will establish three Geoscience and Remote Sensing Laboratories (GSRSL) in three locations with a specific emphasis on the learner, State University of NY at Fredonia (NY), the [Institute for Earth Observations at Palmyra Cove](http://www.palmyracove.org/InstituteforEarthObservations.aspx), and informal science center (NJ), and the **[Hal and Bytte Walker](http://www.meetup.com/Our-Cosmos/events/225823442/)** [GeoSTEM Lab at Los Angeles Southwest College](http://www.meetup.com/Our-Cosmos/events/225823442/) (CA). The three populations that will be engaged are (1) Pre-Service Teachers, (2) In-Service Teachers, and (3) K-16 students. Each GSRL will consist of three components, (1) Earth Observing Satellite Direct Read-out Station, (2) Geographic Information Systems (GIS) Lab, and (3) a Virtual-Reality (VR) Data Visualization Studio. Each location will focus on a specific set of learners. Through these laboratories participants will gain expertise in **geoscience content, data gathering and sources, and the computer science and computational skills involved with the acquisition, analyzation, and applications of these, what are now common place, enormous earth observation datasets often referred to as “Big Data”.** While the instruction strategies will differ from location to location based on the specific community served, there will be a close interaction and sharing of information between the centers creating a GeoSTEM Alliance.

I WILL EXPEXTED OUTCOMES TO THIS SECTION: things like PS will develop instructional strategies and resources, IN-S, lessons. Project investigations, and students will pilot, we can measure learning, interest, career exposure etc.

**NARRATIVE:**

According to the National Academy of Sciences “any thoughtful discussion of STEM education requires a working definition of what constitutes STEM disciplines. While STEM is a term commonly used, an enduring question for policy makers, advocates, researchers, and this committee is what fields of study and practice are included in STEM. Despite legal definitions and the policies based on them, there still is little consensus as to which fields and courses of study should fall within STEM”.

STEM has been previously defined by the National Academy of Engineering and

National Research Council (2009, p.17):

* Science is the study of the natural world, human behavior, interaction, and social and economic systems. It includes studies of the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines.
* Technology comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves.
* Engineering is both a body of knowledge—about the design and creation of human-made products—and a process for solving problems. This process is design under constraint.
* One constraint in engineering design is the laws of nature, or science. Other constraints include factors such as time, money, available materials, ergonomics, environmental regulations, manufacturability, and reparability. Engineering utilizes concepts in science and mathematics as well as technological tools.
* Mathematics is the study of patterns and relationships among quantities, numbers, and shapes. Mathematics includes theoretical mathematics and applied mathematics.

“The National Science Foundation (NSF) also delineates the STEM fields as physical, biological, earth, atmospheric and ocean sciences; mathematics, statistics, and computer sciences; social, behavioral, and economic sciences; and all areas of engineering and technology” (Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways, NAS, pgs. 1-2, 1-3, 2016). Recently, President Obama introduced an initiative noting the role of Computer Science (CS). “It is now time to take the next step forward. Our economy is rapidly shifting, and educators and business leaders are increasingly recognizing that Computer Science (CS) is the new basic” (source: fact Sheet: President Obama Announces Computer Science for All Initiative”, 2016).

Looking through a new lens, Earth SySTEM embraces these views which act as the justification for the introduction of the Geoscience and Remote Sensing Laboratory for the purposes of pre-service teacher preparation, in-service professional development, and opportunities for students of all ages to engage in authentic science investigations and practices that have practical applications to their lives and society. Through learning and applying such skills, students will be visualizing in the future through creating computer generated visualizations of data, but also visualizing their future in terms of 21st century career preparation. Participants will be exposed to the individual STEM components, i.e. geoscience content, technology used in acquiring remotely sensed earth data, the engineering foundation of the creation and operation of these sensors, the accompanying mathematics of the project, and in addition will be acquiring new skillsets associated with these careers of the 21st century.

“Natural and human-induced changes in the Earth system—from our planet’s interior to the land surface, ocean, and atmosphere—affect all aspects of life and society. To understand and respond to these changes and develop tools for decision making, Earth system models assimilate foundational observations collected from the land, sea, air, and space” (NRC, 2008).

In these several past years, we have repeatedly experienced volcanoes, earthquakes, tsunamis, hurricanes, tornadoes, flooding, droughts, and wildfires. As we face future natural and human generated hazards and disasters, the Geosciences have a critical role to play in the public awareness, safety, and national security of our nation, all which impact the US local to national economy.

STEM professionals are using satellite and remote sensing technologies to incorporate imagery, data, real time observations, and modeling into daily decision making on a local to global basis. Geographic Information Systems content is taught as a technical skill, and is used to develop “Geospatial Thinking” and the gathering “Environmental Intelligence” to be used in problem solving in multiply communities, and has become an integral component of data analysis and communication.

“NASA’s Earth Science Division (ESD) conducts a wide range of satellite and suborbital missions to observe Earth’s land surface and interior, biosphere, atmosphere, cryosphere, and oceans as part of a program to improve understanding of Earth as an integrated system. Earth observations provide the foundation for critical scientific advances, and environmental data products derived from these observations are used in resource management and for an extraordinary range of societal applications, including weather forecasts, climate projections, sea level change, water management, disease early warning, agricultural production, and the response to natural disasters” (Continuity of NASA Earth Observations from Space:

A Value Framework, NAS, 2015).

With over five decades of data and imagery from space, the United States continues to enlarge the array of Earth Observing Satellites and remote sensing technologies to monitor above, on, and below the surface of Planet Earth. The American public, government and defense department have come to a point where these data sets are integral in both daily decision making and long term planning. The Geosciences by their very nature are interdisciplinary consisting of a wide area of content and therefore solicits interest from a wide range of diverse students with varying interests and is one of two that can make that claim. The other being Bio-medical. The Geosciences can boast of satellites, aircraft, high altitude balloons, ships, submarines and remote sensors. The result is the daily digital daily geoscience-related data, imagery, and observations and measurements. NOAA claims that they collect over 20 Terabytes/day.

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| The National Aeronautical and Space Administration (NASA), the Department of Commerce (National Oceanic and Atmospheric Administration [NOAA]), and the Department of the Interior (U.S. Geological Survey) are the civil federal agencies with programs that use the vantage point of space to enable these observations, with NASA having a lead role in observations that aim to advance the study of Earth as an integrated dynamic system of chemical, biological, and physical processes—“Earth system science” (Continuity of NASA Earth Observations from Space: A Value Framework, NAS, pg.6).  The geosciences, in the study of the Earth System, including atmosphere, geospace, earth, ocean and polar sciences, faces the growing need to manage, synthesize and understand unprecedented scales, rates, and diversity of data.  According to a “Dear Colleague Letter” (2014) from the Directorate for Geosciences, "Big Data refers to data that challenge existing methods due to size, complexity, or rate of availability. The National Big Data Initiative is a coordinated set of activities involving multiple federal agencies that aims to address this challenge through:   * Advancing the fundamental techniques and technologies for data and knowledge management, data analytics, and data-enabled discovery; * Accelerate scientific and engineering discovery and innovation; * Enabling new fields of inquiry and new modes of discovery and innovation; * Facilitate the development of new data management, data analytics, discovery algorithms and tools; * Enabling scalable, accessible, and sustainable data infrastructure; * Advancing understanding of natural, human and social processes and interactions; * Supporting big data education and workforce development; * Enabling multi-disciplinary collaborative teams and communities to address complex scientific, biomedical, and engineering grand challenges; and * Promoting economic growth and improved health and quality of life.” | |
|  | (Source) NSF 14-069, Big Data For The Geosciences - Calling Attention to Big Data Challenges in the Geosciences, May 9, 2014). |

Earth SySTEM leverages the existing infrastructure and applications of the Geosciences\* in Science, Technology, Engineering, and Mathematics (STEM) Education found in NASA and other federal agencies tasked with providing earth science information. Earth SySTEM utilizes satellite imagery, remote sensing technology, real-time data, and computer visualizations to facilitate interactions between STEM disciplines (\*as defined by the NSF). National STEM education also focuses on the preparation for the careers of the 21st century workforce. Earth SySTEM, while for many introduces the Earth Sciences and the role that satellites and other remote sensing technologies provide to both government and the public, it develops simultaneously academic and technical learning experiences for students that potentially lead to career decisions previously not considered. It allows students to “visualize their future.” Students will gain hands-on exposure to the process of algorithmic thinking and the realization of computational techniques for real world problem solving.

This project proposals the creation of three (3) Geoscience and Remote Sensing Laboratories for the purpose of conducting educational programs and training to three (3) distinct subsets of learners.

1. Pre-Service Teachers
2. In-Service Teachers
3. K-16 students

The Geoscience and Remote Sensing Laboratory will consist of three (3) components to introduce participants to the technology and applications, each having a unique perspective on computer science applications and computational thinking.

1. Earth Observing Satellite Direct Read-Out Station
2. Geographical Information Systems (GIS) Lab
3. Virtual Reality (VR) Visualization Studio

Through the establishment of these Geoscience and Remote Sensing Laboratories, participants will engage in the following three (3) practices:

1. Obtaining Data
2. Direct Read-out
3. Data Portals
4. Field Collection
5. Analyzing Data
6. Geospatial Technologies- GIS/GPS
7. MatLab
8. “R”
9. Image J
10. Multi-Spec
11. Applying Data
12. Authentic Problem Solving
13. Communication (communicating data orally and visually)
14. Societal applications

NEXT STEP IS TO FLESH THESE OUT, Learning outcomes, skillsets etc.